Effect of Welding Parameters on Stainless Steel using SMAW- A Review

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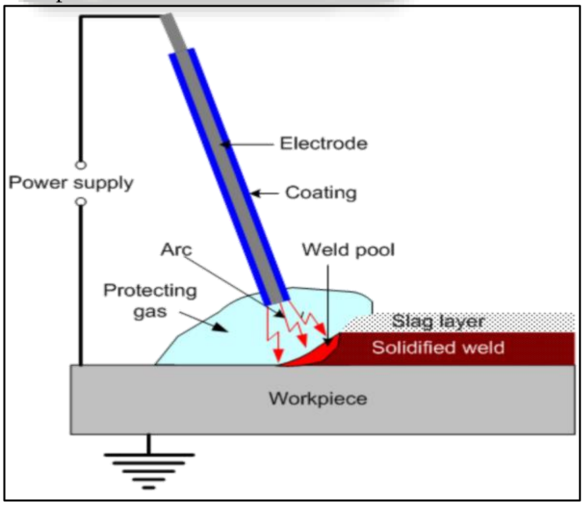
Abstract— Shielded Metal Arc Welding is also known as Manual Metal Arc Welding or Flux Shielded Arc Welding. Smaw is the process that uses a flux-coated electrode from weld. It is a process of metal joining two metal pieces by melting the edges by an electric arc. The electric arc produces between two conductors. The electrode is one conductor and workpiece is another conductor. The electrode and the workpiece are brought nearer with small air gap. Temperature of arc is about 4000c. Electrode used in arc welding arc coated with flux produces gaseous shield around molten metal.

Keywords: Welding Current, Welding Voltage Arc Gap, Welding Speed analysis

I. INTRODUCTION

Shielded metal arc welding (SMAW) method is a fusion welding process in which coalescence of the metals is achieved by the heat from an electric arc between an electrode and the workpiece. This process is one of the most employed processes of fabricating metal components. It is fundamentally a fusion of two or more pieces of metals by the application of heat and sometimes pressure. Thus welding involves a wide range of scientific variables such as time, temperature, electrode, power input and welding speed. In this method, welding parameters are the most important factors affecting the quality, productivity and cost of welding joint. Accordingly, these parameters affecting the arc and welding bath should be estimated and their changing conditions during process must be known before in order to obtain optimum results.



The welding quality of the shielded metal arc welding is determined by the welding parameters including electrode diameter, welding current, welding speed, arc length, electrode advance angle, electrode oscillation angle and movement, welding direction and position, etc. In an effort to obtain high quality welds in shielded metal arc welding method, selection of ideal parameters should be performed according to engineering facts. Commonly, welding parameters are determined by trial and error, based on handbook values, and manufacturers' recommendations.

II. LITERATURE REVIEW

The literatures mainly focus on welding parameters, Welding joint, properties of stainless steel and what is the affect of welding on stainless steel.

Datta et al. (2002) investigated the weldability properties of 20 mm thick plates using the shielded metal arc welding (SMAW) process. The authors suggested that susceptibility of steel to cold cracking is related to the carbon equivalent (CE) and its position in the Graville diagram. High strength, quench and tempered plates having yield strength of 670 MPa (carbon equivalent) are susceptible to a crack-sensitive microstructure and cold cracking during welding.(5)

Vinoth et al. (2015)have investigated a comparison of mechanical properties of 304L austenitic stainless steel weld joint produced by shielding metal arc welding (SMAW), gas metal arc welding (GMAW) and gas tungsten arc welding (GTAW) processes. The 10mm thick SS 304L plate with single V joint configuration was welded with 80A welding current and 20V arc voltage using SMAW process. Experimental results revealed that yield strength, ultimate tensile strength and toughness were superior with the joints produced by GTAW in comparison to SMAW due to more weld penetration at the given weld deposition parameters.(9)

Choubey Rohit jha et.al to study the welding characteristic of different types of weld design and weld metal, the types joint design are v, flat surface to joint by SMAW welding process , varying welding current in all cases. Evaluate all mechanical properties like as % of elongation, tensile strength, yield strength of weld metal and it also show the effect of current on welding speed, yield strength experimentally. The UTS and YS are maximum in V joint design and it conclude that before and at optimum value of UTS, current increase, UTS also increase after optimum value of UTS current increase UTS decrease.(10)

Rajeev Ranjan Et & ALL the goal in this paper is about to, optimize various parameter for SMAW, including welding current, voltage, speed, by developing a mathematical model for a sound weld deposit area of mild steel specimen, the factorial design has been implied to finding various process and parameter,the study revealed that the weld deposited area varies directly with welding voltage and welding current & inverse relationship between speed and weld deposited area. (11)

R.P.singh .R.c.gupta S.C.Sarkar et and all, This paper focuses on simple and accurate model for prediction of weld beads of butt joint by SMAW process. The effect of longitudinal magnetic field generated by bar magnet on weld width was experimentally investigated.(12)

Pravin kumar et In this paper the author using SMAW Welding process investigated the tensile strength of the material with a new concept of vibration which is capable to stir the molten metal before it solidifies .The result shows that the stirring of molten metal increases the welding strength of the material.(13)

III. STAINLESS STEEL

Stainless steel Short arc welding should be used for welding thin materials in the flat position, bridging large gaps and all welding out of position. The best shielding gas to use for short arc welding of stainless steel is A-1025 (90%Helium, 7.5% Argon and 2.5% CO2). This mixture provides good penetration, arc stability, and weld properties (particularly corrosion resistance) in single or multi-pass weld ments. C-25 (75% Ar - 25% CO2) can be used, but only for single pass welds where corrosion resistance of the weld metal is not essential to the end use. CO2 shielding can never be used. Spray arc should be used in the flat position for single or multi- pass welding of thicker material. For spray arc welding, an Ar-1% 02 gas mixture will yield the best results, particularly from the standpoint of bead appearance. If, for a certain application, wetting of the weld bead has proven difficult, an Ar-2% 02 shielding gas mixture will help. However, the chrome oxide build-up will cause the weld bead to be slightly discolored. As for the welding techniques that can be used, the same considerations are true with stainless steel as follow carbon mild steel. However, the forehand technique is sometimes preferred, as a flatter weld can be made, although the surface will be more oxidized.

IV. ABOUT STAINLESS STEEL MATERIAL

There are 2 common grades of stainless: 304L (welded using 308L filler), and 316L which is welded using 316L filler. Why is 308L filler used for 304L? Basically there are a number of grades that do similar jobs, 302L, 303L and 304L, 308L so can be used to weld all 3 grades. Stainless steel is easy to weld but very difficult to keep flat, the coefficient of linear expansion is 1.7 times that of mild steel. There isn't much you can do about that except to weld it quickly and by doing so minimize the heat input. 304 and 316 (as opposed to the L low carbon versions) suffer from weld decay. When heated to welding temperatures the Chromium combines with the Carbon leaving the steel short of Chromium and therefore unable to self-repair itself. This was virtually eliminated by introducing stabilised stainless steels 347 and 321 which contain Niobium or Titanium which sacrifices itself to save the Chromium, however, when lower carbon versions 304L and 316L were introduced the problem of weld decay was eliminated. These days the higher (in fact, normal) carbon versions are only used for applications where heat resistance is needed.

V. SELECTION OF ELECTRODE DIAMETER

The electrodes used in shielded metal arc welding are divided in two main groups as joining and filler welding ones according to the purpose of the welding. The coated electrodes are also classified by the tensile strength of the deposited weld metal, the welding position in which they may used, the preferred type of current and polarity, and the type of coating. The metal wire used in the process is usually from 1.5 to 6.5 mm in diameter and 20 and 45 cm in length. The electrode material in welding is desired to be high strength, ductile and tough. The molten electrodes provide both forming of arc and filling the welding area. According to ISO 2560:2005 standard, the electrodes are determined in the welding for plain carbon and low alloy steels. For selection of electrode; material type, welding position, welding current, welding slot form and work piece thickness above all are taken into consideration. The electrode diameter changes according to the material thickness and welding slot form. The most used electrodes in shielded metal arc welding applications are 2.50,3.15 and 4.00 mm core diameter.

VI. ELECTRODE ADVANCE ANGLE

The molten metal can be transferred by arc along the welding process and the welder should orientate the arc to form melting on joining surfaces. The angle between electrode and advance direction is generally 45 to 70°, however this value can also be changed between 45 to 90°. The main principle here is the angle should prevent the flowing of slag in front of arc excluding vertical welding from top to down. Welding seam form changes in case of lowering tolerances and linear curves are extremely decreases, and burning grooves are seen in borders and penetration is reduced. Similar alteration in seam welding is obtained if tolerances are passed over, and arc blowing is realized (below 50°) and damage in borders is formed.

VII. ARC WELDING FAULTS

Arc Length Faults:-Beginners will commonly have too long an arc length and too great a lead angle. An excessive rod lead angle will also increase the arc length.

1) Arc Length Too Short:-This weld was laid with the end of the rod covered by the molten slag. The surface of the weld is uneven where it has been dragged along by the rod, and the weld will be low on power and contain slag inclusions.
2) Arc Length OK:-A normal arc weld. The weld has a consistent profile and minimal spatter.
3) Arc Length Too Long:-Too great a distance between the rod and the work will increase the voltage resulting in a flat and wide weld with a great deal of spatter. It also makes the arc unstable, and the slag will be difficult to remove from the edges of the weld. Sectioning this weld reveals undercutting to the left side.

Arc welding is a constant current process, but the arc length has an effect on voltage. Reducing the arc length will decrease the voltage, and this reduces the heat in the weld. Increasing arc length will increase the voltage. Arc length faults can share many similarities with the current faults later on this page.

In this parameters arc gap is too short and too long and the results are in this photo.

VIII. TRAVEL SPEED FAULTS

Beginner welders tend to move the rod too quickly, especially those who are transitioning to arc welding from another welding process. The pool of molten slag is wide, tall and bubbly.

The weld underneath the slag will be about half the width of the molten slag pool, and it takes longer than might be expected to build it up. Experienced arc welders say they can see the weld through the slag pool.

1) Speed Too Fast:-Excessive speed results in a thin, weak bead. The ridges in the weld are elongated and triangular. Had the current been increased to compensate for the speed the ridges would still remain elongated.
2) Speed Too Slow:-Welding too slowly results in a wide tall build-up of weld. The shape of the weld is not consistent as the weld pool has built up and then collapsed into the crater. The poor control of the weld pool can result in cold joints and slag inclusions.

In this parameters welding speed is too fast and too slow and results are in this photo

IX. CURRENT SETTING FAULTS

Welding rod boxes are marked with their recommended current. For my 308L rods the 3.15mm rods are marked 70 to 95 amps DC. Where in the range you work will depend on the position of the work, but for beginners setting the amps right in the middle of the range should rule out most faults due to incorrect amps.

1) Amps too low:-Setting the amps too low will result in a tall, narrow bead lacking in penetration. The weld will be difficult to start and the arc prone to straying towards one side of a joint in preference to the other.
2) Amps too high:-The bead is wide, flat and irregular, and a small undercut can be seen on the right of the weld. A deep crater has formed at the end of the weld, and the slag is difficult to remove from the edges of the weld. Excessive current should not be compensated by excessive travel speed. This can result in slag inclusions due to rapid cooling of the weld.
3) Amps OK:-With the amps set correctly the bead is a consistent rounded shape, and the slag is easy to remove.

In this photo we set amp.50,60,70 and 90 and the results are in this photo.

X. WELDING VOLTAGE

High voltage produces a wide bead shape that is subjected to cracking, increase undercut and creates difficulty in removing slag. Lowering the voltage produces stiffer arc, which improves penetration in a deep weld groove and resist arc blow. Low voltage produces a narrow bead and causes difficult slag removal along the bead edges.

1) Voltage is too high: When voltage is too high too much voltage is marked by poor control, inconsistent penetration and a turbulent weld pool that fails to consistently penetrate the base material.
2) Voltage is too Low: When voltage is too low too little voltage results in poor arc starts, control and penetration. It also causes excessive spatter, a convex bead profile and poor tie-in at the toes of weld.

In this photo we welding on stainless steel voltage parameters when voltage is minimum, average, maximum and results are in this photo.

XI. WELDING PARAMETERS

After having selected the electrode for a weld, operating conditions must be chosen. The four important parameters are the welding current, arc gap, welding voltage and arc travel speed. These parameters will affect the weld characteristics to a great extent. Because these factors can be varied over a large range, they are considered the primary adjustments in any welding operation. The values should be recorded for every different type of weld to permit reproducibility.

1) Welding current:-The welding current or amperage is essential to producing welds with good appearance and the required strength characteristics. The welder controls the amperage variable by setting the amperage on the welding machine prior to welding.
2) Welding voltage:-Welding voltage varies with the length of the arc between the electrode and molten weld metal. With the increase in arc length, the arc voltage increases because lengthening of the arc exposes more of the arc column to the cool boundary of the arc.
3) Welding speed:-Speed of welding is defined as the rate of travel of the electrode along the seam or the rate of the travel of the work under the electrode along the seam. Some general statements can be made regarding speed of travel. Increasing the speed of travel and maintaining constant arc voltage and current will reduce the width of bead and also increase penetration until an optimum speed is reached at which penetration will be maximum.
4) Arc Gap:-When electricity is made to jump across a gap it is said to arc across the gap. In Shielded Metal Arc Welding (Stick) it is this arcing effect that creates the intense heat required for melting the electrode and the base metal together.

The arc is the term used to describe the distance from the tip of the electrode to the base metal and can be varied from lightly touching the metal at an angle sufficient to maintain an arc to a distance far enough from the base metal to extinguish the arc.

Arc length should be as short as possible. Too long arc dissipates the heat into the air, increases spatter & slows down the speed of welding. It also results in Nitrogen pick up by the weld metal. In DC welding a long arc is more susceptible to arc blow than a short arc.

XII. THE CHALLENGES OF WELDING STAINLESS STEEL

The microstructure of the stainless steel has an influence on the metal's properties and on their welding characteristics. The weldability of the various classifications of stainless steel varies due to the different chemical compositions, crystal structure as well as the resultant reactions of these to the thermal cycles of welding.

A major problem of welding stainless steel is the prevention of sensitization which is when the corrosion resistant characteristics of the steel may be adversely affected by heat in the heat affected zone (HAZ).

The addition of chromium is what gives iron-based materials a certain resistance to rusting and corrosion as it helps produce a tough and impervious layer on the surface of the material. On a sensitised joint, on both sides of the weld bead, a certain portion of the metal becomes depleted of chromium and loses its anticorrosive properties which means the welded metal is now prone to corrosion.

While the physical properties may different between the various classifications of stainless steel, the general properties of major influence are:

1) The coefficient of thermal expansion
2) The thermal conductivity
3) The electrical resistivity
4) The melting temperatures.

1) Coefficient of Thermal Expansion:-Austenitic stainless steel will expand at a greater rate than mild steel and allowances must be made for this expansion and contraction to control distortion and thermal stress, particularly during cooling which can cause weld zone cracking.
2) Thermal Conductivity:-Austenitic steels in particular conduct heat more slowly. This promotes sharp temperature gradients which along with high thermal expansion causes distortion to be confined to a small area. When welding stainless steel, it is important that the weld zone remains at a higher temperature for a longer time to control interpass temperatures.
3) Electrical Resistance:-The higher electrical resistance of stainless steel will result in the generation of more heat for the same current. This, coupled with low heat conductivity, is an advantage when using resistance welding processes. However, if not controlled in other welding processes, this will result in too great a heat input.
4) In shielded metal arc welding (SMAW), the use of too high a welding current will cause overheating of the core wire of the electrode and also damage to the flux coating.
5) Melting Temperatures:-Stainless steel has a lower melting temperature than mild steel, which is an advantage because less heat is required to produce fusion. This results in faster welding for the same heat. One must be careful, however when changing from welding mild steel to welding stainless steel.

Appropriate actions should be taken to avoid or minimize possible detrimental effects on the steel such as distortion and excessive heat input. These can include using smaller and more frequent tack welds, step welding and the use of copper back-up bars and chill plates.

XIII. Conclusion

Welding parameters such as welding current, speed, voltage and arc gap are the most significant parameters in the welding process. Thus, these parameters should be properly adjusted to maximize the mechanical properties of the welds because any change in any of the parameter scan significantly affects all other parameters as well. For example, if a high level of welding current or welding amp is selected during welding, then this leads to more fusion/melting at the joined region due to grain coarsening effects and other structural changes.

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